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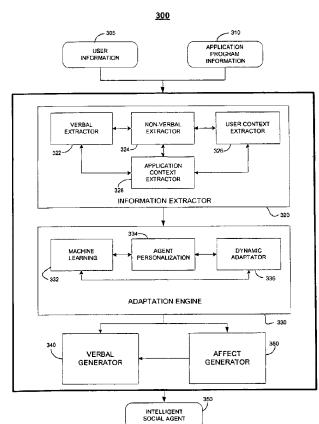|		
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(54) Title: INTELLIGENT PERSONAL ASSISTANTS

(57) Abstract: An intelligent social agent is an animated computer interface agent with social intelligence that has been developed for a given application or type of applications and a particular user population. The social intelligence of the agent comes from the ability of the agent to be appealing, affective, adaptive, and an appropriate when interacting with the user. An intelligent personal assistant is an implementation of an intelligent social agent that assists a user in operating a computing device and using application programs on a computing device.

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INTELLIGENT PERSONAL ASSISTANTS

TECHNICAL FIELD

This description relates to techniques for developing and using a computer interface agent to assist a computer system user.

BACKGROUND

5   A computer system may be used to accomplish many tasks. A user of a computer system may be assisted by a computer interface agent that provides information to the user or performs a service for the user.

SUMMARY

10   In one general aspect, implementing an intelligent personal assistant includes receiving an input associated with a user and an input associated with an application program, and accessing a user profile associated with the user. Context information is extracted from the received input, and the context information and the user profile are processed to produce an adaptive response by the intelligent personal assistant.

15   Implementations may include one or more of the following features. For example, the application program may be a personal information management application program, an application program to operate a computing device, an entertainment application program, or a game.

An adaptive response by the intelligent personal assistant may be associated with

20   a personal information management application program, an application program to operate a computing device, an entertainment application program, or a game.

In another general aspect, an apparatus for implementing an intelligent social agent includes an information extractor, an adaptation engine, and an output generator. The information extractor is configured to access a user profile associated with the user,

25   receive an input associated with a user, and extract context information from the received input. The adaptation engine is configured to receive the context information and the user profile from the information extractor and process the context information and the user

profile to produce an adaptive output. The output generator is configured to receive the adaptive output and represent the adaptive output in the intelligent social agent.

Implementations may include one or more of the features noted above and one or more of the following features. For example, the information extractor may be configured to receive physiological data or application program information associated with the user. The information extractor may be configured to extract information about an affective state of the user from physiological information associated with the user, vocal analysis information associated with the user by extracting verbal content and analyzing speech characteristics of the user, or verbal information from the user. Extracting context information also may include extracting a geographical position of the user and extracting information based on the geographical position of the user by using a global positioning system. Extracting context information may include extracting information about the application context associated with the user or about a linguistic style of the user.

An output generator may be a verbal generator, the adaptation engine may be configured to produce a verbal expression, and the verbal generator may produce the verbal expression in the intelligent social agent. An output generator may be an affect generator, the adaptation engine may be configured to produce a facial expression, and the affect generator may produce the facial expression in the intelligent social agent. The output generator may be a multi-modal generator that represents an adaptive output in the intelligent social agent using at least one of two modes. One mode may be a verbal mode and another mode may be an affect mode. The adaptive engine may be configured to produce a facial expression and a verbal expression that is represented in the intelligent social agent by the multi-modal output generator. The adaptation engine may be configured to produce an emotional expression in the intelligent social agent. The output generator may be configured to represent the emotional expression in the intelligent social agent.

In yet another general aspect, implementing an intelligent social agent includes receiving an input associated with a user, accessing a user profile associated with the user, extracting context information from the received input, and processing the context information and the user profile to produce an adaptive output to be represented by the intelligent social agent.

Implementations may include one of more of the features noted above or one or more of the following features. For example, the input associated with the user may include physiological data or application program information associated with the user. Extracting context information may include extracting information about an affective

5 state of the user from physiological information, vocal analysis information, or verbal information associated with a user. Extracting context information also may include extracting a geographical position of the user and extracting information based on the geographical position of the user. Extracting context information may include extracting information about the application context associated with the user or about a linguistic

10 style of the user. An adaptive output to be represented by the intelligent social agent may be a verbal expression, a facial expression, or an emotional expression.

Implementations of any of the techniques described above may include a method or process, a computer program on computer-readable media, a system or an apparatus, or a mobile device for implementing an intelligent social agent that interacts with a user or

15 other type of system.

The details of one or more of the implementations are set forth in the accompanying drawings and description below. Other features and advantages will be apparent from the descriptions and drawings, and from the claims.

DESCRIPTION OF THE DRAWINGS

20 FIG. 1 is a block diagram of a programmable system for developing and using an intelligent social agent.

FIG. 2 is a block diagram of a computing device on which an intelligent social agent operates.

FIG. 3 is a block diagram illustrating an architecture of a social intelligence

25 engine.

FIGS. 4A and 4B are flow charts of processes for extracting affective and physiological states of the user.

FIG. 5 is a flow chart of a process for adapting an intelligent social agent to the user and the context.

30 FIG. 6 is a flow chart of a process for casting an intelligent social agent.

FIGS. 7-10 are block diagrams showing various aspects of an architecture of an intelligent personal assistant.

Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

5   Referring to FIG. 1, a programmable system 100 for developing and using an intelligent social agent includes a variety of input/output (I/O) devices (e.g., a mouse 102, a keyboard 103, a display 104, a voice recognition and speech synthesis device 105, a video camera 106, a touch input device with stylus 107, a personal digital assistant or "PDA" 108, and a mobile phone 109) operable to communicate with a computer 110

10   having a central processor unit (CPU) 120, an I/O unit 130, a memory 140, and a data storage device 150. Data storage device 150 may store machine-executable instructions, data (such as configuration data or other types of application program data), and various programs such as an operating system 152 and one or more application programs 154 for developing and using an intelligent social agent, all of which may be processed by CPU

15   120. Each computer program may be implemented in a high-level procedural or object-oriented programming language, or in assembly or machine language if desired; and in any case, the language may be a compiled or interpreted language. Data storage device 150 may be any form of non-volatile memory, including by way of example semiconductor memory devices, such as Erasable Programmable Read-Only Memory

20   (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and Compact Disc Read-Only Memory (CD-ROM).

System 100 also may include a communications card or device 160 (e.g., a modem and/or a network adapter) for exchanging data with a network 170 using a

25   communications link 175 (e.g., a telephone line, a wireless network link, a wired network link, or a cable network). Alternatively, a universal system bus (USB) connector may be used to connect system 100 for exchanging data with a network 170. Other examples of system 100 may include a handheld device, a workstation, a server, a device, or some combination of these capable of responding to and executing instructions in a defined

30   manner. Any of the foregoing may be supplemented by, or incorporated in, ASICs (application-specific integrated circuits).

Although FIG 1 illustrates a PDA and a mobile phone as being peripheral with respect to system 100, in some implementations, the functionality of the system 100 may be directly integrated into the PDA or mobile phone.

FIG 2 shows an exemplary implementation of intelligent social agent 200 for a computing device including a PDA 210, a stylus 212, and a visual representation of a intelligent social agent 220. Although FIG 2 shows an intelligent social agent as an animated talking head style character, an intelligent social agent is not limited to such an appearance and may be represented as, for example, a cartoon head, an animal, an image captured from a video or still image, a graphical object, or as a voice only. The user may select the parameters that define the appearance of the social agent. The PDA may be, for example, an iPAQ™ Pocket PC available from COMPAQ.

An intelligent social agent 200 is an animated computer interface agent with social intelligence that has been developed for a given application or device or a target user population. The social intelligence of the agent comes from the ability of the agent to be appealing, affective, adaptive, and appropriate when interacting with the user. Creating the visual appearance, voice, and personality of an intelligent social agent that is based on the personal and professional characteristics of the target user population may help the intelligent social agent be appealing to the target users. Programming an intelligent social agent to manifest affect through facial, vocal and linguistic expressions may help the intelligent social agent appear affective to the target users. Programming an intelligent social agent to modify its behavior for the user, application, and current context may help the intelligent social agent be adaptive and appropriate to the target users. The interaction between the intelligent social agent and the user may result in an improved experience for the user as the agent assists the user in operating a computing device or computing device application program.

FIG 3 illustrates an architecture of a social intelligence engine 300 that may enable an intelligent social agent to be appealing, affective, adaptive, and appropriate when interacting with a user. The social intelligence engine 300 receives information from and about the user 305 that may include a user profile, and from and about the application program 310. The social intelligence engine 300 produces behaviors and verbal and nonverbal expressions for an intelligent social agent.

The user may interact with the social intelligence engine 300 by speaking, entering text, using a pointing device, or using other types of I/O devices (such as a touch

screen or vision tracking device). Text or speech may be processed by a natural language processing system and received by the social intelligence engine as a text input. Speech will be recognized by speech recognition software and may be processed by a vocal feature analyzer that provides a profile of the affective and physiological states of the user

5   based on characteristics of the user's speech, such as pitch range and breathiness.

Information about the user may be received by the social intelligence engine 300. The social intelligence engine 300 may receive personal characteristics (such as name, age, gender, ethnicity or national origin information, and preferred language) about the user, and professional characteristics about the user (such as occupation, position of

10   employment, and one or more affiliated organizations). The user information received may include a user profile or may be used by the central processor unit 120 to generate and store a user profile.

Non-verbal information received from a vocal feature analyzer or natural language processing system may include vocal cues from the user (such as fundamental pitch and

15   speech rate). A video camera or a vision tracking device may provide non-verbal data about the user's eye focus, head orientation, and other body position information. A physical connection between the user and an I/O device (such as a keyboard, a mouse, a handheld device, or a touch pad) may provide physiological information (such as a measurement of the user's heart rate, blood pressure, respiration, temperature, and skin

20   conductivity). A global positioning system may provide information about the user's geographic location. Other such contextual awareness tools may provide additional information about a user's environment, such as a video camera that provides one or more images of the physical location of the user that may be processed for contextual information, such as whether the user is alone or in a group, inside a building in an office

25   setting, or outside in a park.

The social intelligence engine 300 also may receive information from and about an application program 310 running on the computer 110. The information from the application program 310 is received by the information extractor 320 of the social intelligence engine 300. The information extractor 320 includes a verbal extractor 322, a

30   non-verbal extractor 324, and a user context extractor 326.

The verbal extractor 322 processes verbal data entered by the user. The verbal extractor may receive data from the I/O device used by the user or may receive data after processing (such as text generated by a natural language processing system from the

original input of the user). The verbal extractor 322 captures verbal content, such as commands or data entered by the user for a computing device or an application program (such as those associated with the computer 110). The verbal extractor 322 also parses the verbal content to determine the linguistic style of the user, such as word choice,

5   grammar choice, and syntax style.

The verbal extractor 322 captures verbal content of an application program, including functions and data. For example, functions in an email application program may include viewing an email message, writing an email message, and deleting an email message, and data in an email message may include the words included in a subject line,

10   identification of the sender, time that the message was sent, and words in the email message body. An electronic commerce application program may include functions such as searching for a particular product, creating an order, and checking a product price and data such as product names, product descriptions, product prices, and orders.

The nonverbal extractor 324 processes information about the physiological and

15   affective states of the user. The nonverbal extractor 324 determines the physiological and affective states of the user from 1) physiological data, such as heart rate, blood pressure, blood pulse volume, respiration, temperature, and skin conductivity; 2) from the voice feature data such as speech rate and amplitude; and 3) from the user's verbal content that reveals affective information such as "I am so happy" or "I am tired". Physiological data

20   provide rich cues to induce a user's emotional state. For example, an accelerated heart rate may be associated with fear or anger and a slow heart rate may indicate a relaxed state. Physiological data may be determined using a device that attaches from the computer 110 to a user's finger and is capable of detecting the heart rate, respiration rate, and blood pressure of the user. The nonverbal extraction process is described in FIG. 4.

25   The user context extractor 326 determines the internal context and external context of the user. The user context extractor 326 determines the mode in which the user requests or executes an action (which may be referred to as internal context) based on the user's physiological data and verbal data. For example, the command to show sales figures for a particular period of time may indicate an internal context of urgency when

30   the words are spoken with a faster speech rate, less articulation, and faster heart rate than when the same words are spoken with a normal style for the user. The user context extractor 326 may determine an urgent internal context from the verbal content of the command, such as when the command includes the term "quickly" or "now".

The user context extractor 326 determines the characteristics for the user's environment (which may be referred to as the external context of the user). For example, a global positioning system (integrated within or connected to the computer 110) may determine the geographic location of the user from which the user's local weather

5   conditions, geology, culture, and language may be determined. The noise level in the user's environment may be determined, for instance, through a natural language processing system or vocal feature analyzer stored on the computer 110 that processes audio data detected through a microphone integrated within or connected to the computer 110. By analyzing images from a video camera or vision tracking device, the user context

10   extractor 326 may be able to determine other physical and social environment characteristics, such as whether the user is alone or with others, located in an office setting, or in a park or automobile.

The application context extractor 328 determines information about the application program context. This information may, for example, include the importance

15   of an application program, the urgency associated with a particular action, the level of consequence of a particular action, the level of confidentiality of the application or the data used in the application program, frequency that the user interacts with the application program or a function in the application program, the level of complexity of the application program, whether the application program is for personal use or in an

20   employment setting, whether the application program is used for entertainment, and the level of computing device resources required by the application program.

The information extractor 320 sends the information captured and compiled by the verbal extractor 322, the non-verbal extractor 324, the user context extractor 326, and the application context extractor 328 to the adaptation engine 330. The adaptation engine

25   330 includes a machine learning module 332, an agent personalization module 334, and a dynamic adaptor module 336.

The machine learning module 332 receives information from the information extractor 320 and also receives personal and professional information about the user. The machine learning module 332 determines a basic profile of the user that includes

30   information about the verbal and non-verbal styles of the user, application program usage patterns, and the internal and external context of the user. For example, a basic profile of a user may include that the user typically starts an email application program, a portal, and a list of items to be accomplished from a personal information management system

from after the computing device is activated, the user typically speaks with correct grammar and accurate wording, the internal context of the user is typically hurried, and the external context of the user has a particular level of noise and number of people. The machine learning module 332 modifies the basic profile of the user during interactions

5   between the user and the intelligent social agent.

The machine learning module 332 compares the received information about the user and application content and context with the basic profile of the user. The machine learning module 332 may make the comparison using decision logic stored on the computer 110. For example, when the machine learning module 332 has received

10   information that the heart rate of the user is 90 beats per minute, the machine learning module 332 compares the received heart rate with the typical heart rate from the basic profile of the user to determine the difference between the typical and received heart rates, and if the heart rate is elevated a certain number of beats per minute or a certain percentage, the machine learning module 332 determines the heart rate of the user is

15   significantly elevated and a corresponding emotional state is evident in the user.

The machine learning module 332 produces a dynamic digest about the user, the application, the context, and the input received from the user. The dynamic digest may list the inputs received by the machine learning module 332, any intermediate values processed (such as the difference between the typical heart rate and current heart rate of

20   the user), and any determinations made (such as the user is angry based on an elevated heart rate and speech change or semantics indicating anger). The machine learning module 332 uses the dynamic digest to update the basic profile of the user. For example, if the dynamic digest indicates that the user has an elevated heart rate, the machine learning module 332 may so indicate in the current physiological profile section of the

25   user's basic profile. The agent personalization module 334 and the dynamic adaptor module 336 may also use the dynamic digest.

The agent personalization module 334 receives the basic profile of the user and the dynamic digest about the user from the machine learning module 332. Alternatively, the agent personalization module 334 may access the basic profile of the user or the

30   dynamic digest about the user from the data storage device 150. The agent personalization module 334 creates a visual appearance and voice for an intelligent social agent (which may be referred to as casting the intelligent social agent) that may be appealing and appropriate for a particular user population and adapts the intelligent social

agent to fit the user and the user's changing circumstances as the intelligent social agent interacts with the user (which may be referred to as personalizing the intelligent social agent).

The dynamic adaptor module 336 receives the adjusted basic profile of the user and the dynamic digest about the user from the machine learning module 332 and information received or compiled by the information extractor 320. The dynamic adaptor module 336 also receives casting and personalization information about the intelligent social agent from the agent personalization module 334.

The dynamic adaptor module 336 determines the actions and behavior of the intelligent social agent. The dynamic adaptor module 336 may use verbal input from the user and the application program context to determine the one or more actions that the intelligent social agent should perform. For example, when the user enters a request to "check my email messages" and the email application program is not activated, the intelligent social agent activates the email application program and initiates the email application function to check email messages. The dynamic adaptor module 336 may use nonverbal information about the user and contextual information about the user and the application program to help ensure that the behaviors and actions of the intelligent social agent are appropriate for the context of the user.

For example, when the machine learning module 332 indicates that the user's internal context is urgent, the dynamic adaptor module 336 may adjust the intelligent social agent so that the agent has a facial expression that looks serious and stops or pauses a non-critical function (such as receiving a large data file from a network) or closing unnecessary application programs (such as a drawing program) to accomplish a requested urgent action as quickly as possible.

When the machine learning module 332 indicates that the user is fatigued, the dynamic adaptor module 336 may adjust the intelligent social agent so that the agent has a relaxed facial expression, speaks more slowly, and uses words with fewer syllables, and sentences with fewer words.

When the machine learning module 332 indicates that the user is happy or energetic, the dynamic adaptor module 336 may adjust the intelligent social agent to have a happy facial expression and speak faster. The dynamic adaptor module 336 may have

the intelligent social agent to suggest additional purchases or upgrades when the user is placing an order using an electronic commerce application program.

When the machine learning module 332 indicates that the user is frustrated, the dynamic adaptor module 336 may adjust the intelligent social agent to have a concerned facial expression and make fewer or only critical suggestions. If the machine learning module 332 indicates that the user is frustrated with the intelligent social agent, the dynamic adaptor module 336 may have the intelligent social agent apologize and explain sensibly what is the problem and how it should be fixed.

The dynamic adaptor module 336 may adjust the intelligent social agent to behave based on the familiarity of the user with the current computer device, application program, or application program function and the complexity of the application program. For example, when the application program is complex and the user is not familiar with the application program (e.g., the user is using an application program for the first time or the user has not used the application program for some predetermined period of time), the dynamic adaptor module 336 may have the intelligent social agent ask the user whether the user would like help, and, if the user so indicates, the intelligent social agent starts a help function for the application program. When the application program is not complex or the user is familiar with the application program, the dynamic adaptor module 336 typically does not have the intelligent social agent offer help to the user.

The verbal generator 340 receives information from the adaptation engine 330 and produces verbal expressions for the intelligent social agent 350. The verbal generator 340 may receive the appropriate verbal expression for the intelligent social agent from the dynamic adaptor module 336. The verbal generator 340 uses information from the machine learning module 332 to produce the specific content and linguistic style for the intelligent social agent 350.

The verbal generator 340 then sends the textual verbal content to an I/O device for the computer device, typically a display device, or a text-to-speech generation program that converts the text to speech and sends the speech to a speech synthesizer.

The affect generator 360 receives information from the adaptation engine 330 and produces the affective expression for the intelligent social agent 350. The affect generator 360 produces facial expressions and vocal expressions for the intelligent social agent 350 based on an indication from the dynamic adaptor module 336 as to what emotion the

intelligent social agent 350 should express. A process for generating affect is described with respect to FIG. 5.

Referring to FIG. 4A, a process 400A controls a processor to extract nonverbal information and determine the affective state of the user. The process 400A is initiated by receiving physiological state data about the user (step 410A). Physiological state data may include autonomic data, such as heart rate, blood pressure, respiration rate, temperature, and skin conductivity. Physiological data may be determined using a device that attaches from the computer 110 to a user's finger or palm and is capable of detecting the heart rate, respiration rate, and blood pressure of the user.

The processor then tentatively determines a hypothesis for the affective state of the user based on the physiological data received through the physiological channel (step 415A). The processor may use predetermined decision logic that correlates particular physiological responses with an affective state. As described above with respect to FIG. 3, an accelerated heart rate may be associated with fear or anger and a slow heart rate may indicate a relaxed state.

The second channel of data received by the processor to determine the user's affective state is the vocal analysis data (step 420A), such as the pitch range, the volume, and the degree of breathiness in the speech of the user. For example, louder and faster speech compared to the user's basic pattern may indicate that a user is happy. Similarly, quieter and slower speech than normal may indicate that a user is sad. The processor then determines a hypothesis for the affective state of the user based on the vocal analysis data received through the vocal feature channel (step 425A).

The third channel of data received by the processor for determining the user's affective state is the user's verbal content that reveals the user's emotions (step 430A). Examples of such verbal content include phrases such as "Wow, this is great" or "What? The file disappeared?". The processor then determines a hypothesis for the affective state of the user based on the verbal content received through the verbal channel (step 435A).

The processor then integrates the affective state hypotheses based on the data from the physiological channel, the vocal feature channel, and the verbal channel, resolves any conflict, and determines a conclusive affective state of the user (step 440A). Conflict resolution may be accomplished through predetermined decision logic. A confidence coefficient is given to the affective state predicted by each of the three channels based on

the inherent predictive power of that channel for that particular emotion and the unambiguity level of the specific diagnosis of the emotional state in occurrence. Then the processor disambiguates by comparing and integrating the confidence coefficients.

Some implementations may receive either physiological data, vocal analysis data, verbal content, or a combination. When only one type of data is received, integration (step 440A) may not be performed. For example, when only physiological data is received, steps 420A-440A are not performed and the processor uses the affective state of the user based on physiological data as the affective state of the user. Similarly, when only vocal analysis data is received, the process is initiated when vocal analysis data is received and steps 410A, 415A, and 430A-445A are not performed. The processor uses the affective state of the user based on vocal analysis data as the affective state of the user.

Similarly, referring to FIG. 4B, a process 400B controls a processor to extract nonverbal information and determine the affective state of the user. The processor receives physiological data about the user (step 410B), vocal analysis data (step 420B), and verbal content that indicates the emotion of the user (step 430B) and determines a hypothesis for the affective state of the user based on each type of data (steps 415B, 425B, and 435B) in parallel. The processor then integrates the affective state hypotheses based on the data from the physiological channel, the vocal feature channel, and the verbal channel, resolves any conflict, and determines a conclusive affective state of the user (step 440B) as described with respect to FIG. 4A.

Referring to FIG. 5, a process 500 controls a processor to adapt an intelligent social agent to the user and the context. The process 500 may help an intelligent social agent to act appropriately based on the user and the application context.

The process 500 is initiated when content and contextual information is received (step 510) by the processor from an input/output device (such as a voice recognition and speech synthesis device, a video camera, or physiological detection device connected to a finger of the user) to the computer 110. The content and contextual information received may be verbal information, nonverbal information, or contextual information received from the user or application program or may be information compiled by an information extractor (as described previously with respect to FIG. 3).

The processor then accesses data storage device 150 to determine the basic user profile for the user with whom the intelligent social agent is interacting (step 515). The

basic user profile includes personal characteristics (such as name, age, gender, ethnicity or national origin information, and preferred language) about the user, professional characteristics about the user (such as occupation, position of employment, and one or more affiliated organizations), and non-verbal information about the user (such as

5   linguistic style and physiological profile information). The basic user profile information may be received during a registration process for a product that hosts an intelligent social agent or by a casting process to create an intelligent social agent for a user and stored on the computing device.

The processor may adjust the context and content information received based on

10   the basic user profile information (step 520). For example, a verbal instruction to "read email messages now" may be received. Typically, a verbal instruction modified with the term "now" may result in a user context mode of "urgent." However, when the basic user profile information indicates that the user typically uses the term "now" as part of an instruction, the user context mode may be changed to "normal".

15   The processor may adjust the content and context information received by determining the affective state of the user. The affective state of the user may be determined from content and context information (such as physiological data or vocal analysis data).

The processor modifies the intelligent social agent based on the adjusted content

20   and context information (step 525). For example, the processor may modify the linguistic style and speech style of the intelligent social agent to be more similar to the linguistic style and speech style of the user.

The processor then performs essential actions in the application program (step 530). For example, when the user enters a request to "check my email messages" and the

25   email application program is not activated, the intelligent social agent activates the email application program and initiates the email application function to check email messages (as described previously with respect to FIG. 3).

The processor determines the appropriate verbal expression (step 535) and an appropriate emotional expression for the intelligent social agent (step 540) that may

30   include a facial expression.

The processor generates an appropriate verbal expression for the intelligent social agent (step 545). The appropriate verbal expression includes the appropriate verbal

content and appropriate emotional semantics based on the content and contextual information received, the basic user profile information, or a combination of the basic user profile information and the content and contextual information received.

For example, words that have affective connotation may be used to match the appropriate emotion that the agent should express. This may be accomplished by using an electronic lexicon that associates a word with an affective state, such as associating the word "fantastic" with happiness, the word "delay" with frustration, and so on. The processor selects the word from the lexicon that is appropriate for the user and the context. Similarly, the processor may increase the number of words used in a verbal expression when the affective state of the user is happy or may decrease the number of words used or use words with fewer syllables if the affective state of the user is sad.

The processor may send the verbal expression text to an I/O device for the computer device, typically a display device. The processor may convert the verbal expression text to speech and output the speech. This may be accomplished using a text-to-speech conversion program and a speech synthesizer.

In the meantime, the processor generates an appropriate affect for the facial expression of the intelligent social agent (step 550). Otherwise, a default facial expression may be selected. A default facial expression may be determined by the application, the role of the agent, and the target user population. In general, an intelligent social agent by default may be slightly friendly, smiling, and pleasant.

Facial emotional expressions may be accomplished by modifying portions of the face of the intelligent social agent to show affect. For example, surprise may be indicated by showing the eyebrows raised (e.g., curved and high), skin below brow stretched horizontally, wrinkles across forehead, eyelids opened, and the white of the eye is visible, jaw open without tension or stretching of the mouth.

Fear may be indicated by showing the eyebrows raised and drawn together, forehead wrinkles drawn to the center of the forehead, upper eyelid is raised and lower eyelid is drawn up, mouth open, and lips slightly tense or stretched and drawn back. Disgust may be indicated by showing upper lip is raised, lower lip is raised and pushed up to upper lip or lower lip is lowered, nose is wrinkled, cheeks are raised, lines appear below the lower lid, lid is pushed up but not tense, and brows are lowered. Anger may be indicated by eyebrows lowered and drawn together, vertical lines between eyebrows,

lower lid is tensed, upper lid is tense, eyes have a hard stare, and eyes have a bulging appearance, lips are either pressed firmly together or tensed in a square shape, nostrils may be dilated. Happiness may be indicated by the corners of the lips being drawn back and up, a wrinkle is shown from the nose to the outer edge beyond the lip corners, cheeks

5   are raised, lower eyelid shows wrinkles below it, lower eyelid may be raised but not tense, and crow's-feet wrinkles go outward from the outer corners of the eyes. Sadness may be indicated by drawing the inner corners of eyebrows up, triangulating the skin below the eyebrow, the inner corner of the upper lid and upper corner is raised, and corners of the lips are drawn or lip is trembling.

10   The processor then generates the appropriate affect for the verbal expression of the intelligent social agent (step 555). This may be accomplished by modifying the speech style from the baseline style of speech for the intelligent social agent. Speech style may include speech rate, pitch average, pitch range, intensity, voice quality, pitch changes, and level of articulation. For example, a vocal expression may indicate fear

15   when the speech rate is much faster, the pitch average is very much higher, the pitch range is much wider, the intensity of speech normal, the voice quality irregular, the pitch change is normal, and the articulation precise. Speech style modifications that may connote a particular affective state are set forth in the table below and are further described in Murray, I. R., & Arnott, J. L. (1993), Toward the simulation of emotion in

20   synthetic speech: A review of the literature on human vocal emotion, Journal of Acoustical Society of America, 93, 1097-1108.

	Fear	Anger	Sadness	Happiness	Disgust
Speech Rate	Much Faster	Slightly Faster	Slightly Slower	Faster Or Slower	Very Much Slower
Pitch Average	Very Much Higher	Very Much Higher	Slightly Lower	Much Higher	Very Much Lower
Pitch Range	Much Wider	Much Wider	Slightly Narrower	Much Wider	Slightly Wider
Intensity	Normal	Higher	Lower	Higher	Lower
Voice Quality	Irregular Voicing	Breathy Chest Tone	Resonant	Breathy Blaring	Grumbled Chest Tone
Pitch Changes	Normal	Abrupt On Stressed Syllables	Downward Inflections	Smooth Upward Inflections	Wide Downward Terminal Inflections
Articulation	Precise	Tense	Slurring	Normal	Normal

Referring to FIG. 6, a process 600 controls a processor to create an intelligent social agent for a target user population. This process (which may be referred to as

5   casting an intelligent social agent) may produce an intelligent social agent whose appearance and voice are appealing and appropriate for the target users.

The process 600 begins with the processor accessing user information stored in the basic user profile (step 605). The user information stored within the basic user profile may include personal characteristics (such as name, age, gender, ethnicity or national

10   origin information, and preferred language) about the user and professional characteristics about the user (such as occupation, position of employment, and one or more affiliated organizations).

The processor receives information about the role of the intelligent social agent for one or more particular application programs (step 610). For example, the intelligent

15   social agent may be used as a help agent to provide functional help information about an

17

application program or may be used as an entertainment player in a game application program.

The processor then applies an appeal rule to further analyze the basic user profile and to select a visual appearance for the intelligent social agent that may be appealing to the target user population (step 620). The processor may apply decision logic that associates a particular visual appearance for an intelligent social agent with particular age groups, occupations, gender, or ethnic or cultural groups. For example, decision logic may be based on similarity-attraction (that is, matching the ages, personalities, and ethnical identities of the intelligent social agent and the user). A professional-looking talking-head may be more appropriate for an executive user (such as a chief executive officer or a chief financial officer), and a talking-head with an ultra-modern hair style may be more appealing to an artist.

The processor applies an appropriateness rule to further analyze the basic user profile and to modify the casting of the intelligent social agent (step 630). For example, a male intelligent social agent may be more suitable for technical subject matter, and a female intelligent social agent may be more appropriate for fashion and cosmetics subject matter.

The processor then presents the visual appearance for the intelligent social agent to the user (step 640). Some implementations may allow the user to modify attributes (such as the hair color, eye color, and skin color) of the intelligent social agent or select from among several intelligent social agents with different visual appearances. Some implementations also may allow a user to import a graphical drawing or image to use as the visual appearance for the intelligent social agent.

The processor applies the appeal rule to the stored basic user profile (step 650) and the appropriateness rule to the stored basic user profile to select a voice for the intelligent social agent (step 660). The voice should be appealing to the user and be appropriate for the gender represented by the visual intelligent social agent (e.g., an intelligent social agent with a male visual appearance has a male voice and an intelligent social agent with a female visual appearance has a female voice). The processor may match the user's speech style characteristics (such as speech rate, pitch average, pitch range, and articulation) as appropriate for the voice of the intelligent social agent.

The processor presents the voice choice for the intelligent social agent (step 670). Some implementations may allow the user to modify the speech characteristics for the intelligent social agent.

The processor then associates the intelligent social agent with the particular user
5 (step 680). For example, the processor may associate an intelligent social agent identifier with the intelligent social agent, store the intelligent social agent identifier and characteristics of the intelligent social agent in the data storage device 150 of the computer 110 and store the intelligent social agent identifier with the basic user profile. Some implementations may cast one or more intelligent social agents to be appropriate
10 for a group of users that have similar personal or professional characteristics.

Referring to FIG. 7, an implementation of an intelligent social agent is an intelligent personal assistant. The intelligent personal assistant interacts with a user of the computing device such as computing device 210 to assist the user in operating the computing device 210 and using application programs. The intelligent personal assistant
15 assists the user of the computing device to manage personal information, operate the computing device 210 or one or more application programs running on the computing device, and use the computing device for entertainment.

The intelligent personal assistant may operate on a mobile computing device, such as a PDA, laptop, or mobile phone, or a hybrid device including the functions associated
20 with a PDA, laptop, or mobile phone. When an intelligent personal assistant operates on a mobile computing device, the intelligent personal assistant may be referred to as an intelligent mobile personal assistant. The intelligent personal assistant also may operate on a stationary computing device, such as a desktop personal computer or workstation, and may operate on a system of networked computing devices, as described with respect
25 to FIG. 1.

FIG. 7 illustrates one implementation of an architecture 700 for an intelligent personal assistant 730. Application program 710, including a personal information management application program 715, one or more entertainment application programs 720, and/or one or more application programs to operate the computing device 725, may
30 run on a computing device, as described with respect to FIG. 1.

The intelligent personal assistant 730 uses the social intelligence engine 735 to interact with a user 740 and the application programs 710. Social intelligence engine 735

is substantially similar to social intelligence engine 300 of FIG. 3. The information extractor 745 of the intelligent personal assistant 730 receives information from and about the application programs 710 and information from and about the user 740, in a similar manner as described with respect to FIG. 3.

5   The intelligent personal assistant 730 processes the extracted information using an adaptation engine 750 and then generates one or more responses (including verbal content and facial expressions) to interact with the user 740 using by the verbal generator 755 and the affect generator 760, in a similar manner as described with respect to FIG. 3. The intelligent personal assistant 730 also may produce one or more responses to operate one

10   or more of the application programs 710 running on the computing device 210, as described with respect to FIGS. 2-3 and FIGS. 8-10. The responses produced may enable the intelligent personal assistant 730 to appear appealing, affective, adaptive, and appropriate when interacting with the user 740. The user 740 also interacts with one or more of the applications programs 710.

15   FIG. 8 illustrates an architecture 800 for implementing an intelligent personal assistant that helps a user to manage personal information. The intelligent personal assistant 810 may assist the user 815 as an assistant that works across all personal information management application program functions. For a business user using a mobile computing device, the intelligent personal assistant 810 may be able to function as

20   an administrative assistant in helping the user manage appointments, email messages, and contact lists. As similarly described with respect to FIGS. 3 and 7, the intelligent personal assistant 810 interacts with the user 815 and the personal information management application program 820 using the social intelligence engine 825, that also includes an information extractor 830, an adaptation engine 835, a verbal generator 840,

25   and an affect generator 845.

          The personal information management application program 820 (which also may be referred to as a PIM) includes email functions 850, calendar functions 855, contact management functions 860, and task list functions 865 (which also may be referred to as a "to do" list). The personal information management application program may be, for

30   example, a version of Microsoft® Outlook®, such as Pocket Outlook®, by Microsoft Corporation, that operates on a PDA.

          The intelligent personal assistant 810 may interact with the user 815 concerning email functions 850. For example, the intelligent personal assistant 810 may report the

status of the user's email account, such as the number of unread messages or the number of unread messages having an urgent status, at the beginning of a work day or when the user requests such an action. The intelligent personal assistant 810 may communicate with the user 815 with a more intense affect about unread messages having an urgent

5   status, or when the number of unread messages is higher than typical for the user 815 (based on intelligent and/or statistical monitoring of typical e-mail patterns). The intelligent personal assistant 810 may notify the user 815 of recently received messages and may communicate with a more intense affect when a recently received message has an urgent status. The intelligent personal assistant 810 may help the user manage

10   messages, such as suggesting messages be deleted or archived based on the user's typical message deletion or archival patterns or when the storage space for messages is reaching or exceeding its limit, or suggesting messages be forwarded to particular users or groups of users based on the user's typical message forwarding patterns.

        The intelligent personal assistant 810 may help the user 815 manage the user's

15   calendar 850. For example, the intelligent personal assistant 810 can report to the user his/her upcoming appointments for the day in the morning or at any time the user desires. The intelligent personal assistant 810 may remind the user 815 of upcoming appointments at a time desired by the user and also decide how far the location of the appointment is from the user's current location. If the user is late or seems late for an

20   appointment, the intelligent personal assistant 810 will accordingly remind him/her in an urgent manner such as speaking a little louder and appearing a little concerned. For example, when a user does not need to travel to an upcoming appointment, such as a business meeting at the office in which the user is located, and the appointment is a regular one in terms of significance and urgency, the intelligent personal assistant 810

25   may remind the user 815 of the appointment in a neutral affect with regular voice tone and facial expression. As the time approaches for an upcoming appointment that requires the user to leave the premises to travel to the appointment, the intelligent personal assistant 810 may remind the user 815 of the appointment in a voice with a higher volume and with more urgent affect.

30   The intelligent personal assistant 810 may help the user 815 enter an appointment in the calendar. For example, the user 815 may verbally describe the appointment using general or relative terms. The intelligent personal assistant 810 transforms the general description of the appointment into information that can be entered into the calendar

application program 860 and sends a command to enter the information into the calendar. For example, the user may say "I have an appointment with Dr. Brown next Thursday at 1." Using the social intelligence engine 825, the intelligent personal assistant 810 may generate the appropriate commands to the calendar application program 860 to enter an

5 appointment in the user's calendar. For example, the intelligent personal assistant 810 may understand that Dr. Brown is the user's physician (possibly by performing a search within the contacts database 860) and that the user will have to travel to the physician's office. The intelligent personal assistant 810 also may look up the address using contact information in the contact management application program 860, and may use a mapping

10 application program to estimate the time required to travel from the user's office address to the doctor's office, and determine the date that corresponds to "next Thursday". The intelligent personal assistant 810 then sends commands to the calendar application program to enter the appointment at 1:00 pm on the appropriate date and to generate a reminder message for a sufficient time before the appointment that allows the user time to

15 travel to the doctor's office.

The intelligent personal assistant 810 also may help the user 815 manage the user's contacts 860. For example, the intelligent personal assistant 810 may enter information for a new contact that the user 815 has spoken to the intelligent personal assistant 810. For example, the user 815 may say "My new doctor is Dr. Brown in

20 Oakdale." The intelligent personal assistant 810 looks up the full name, address, and telephone number of Dr. Brown by using a web site of the user's insurance company that lists the doctors that accept payment from the user's insurance carrier. The intelligent personal assistant 810 then sends commands to the contact application program 860 to enter the contact information. The intelligent personal assistant 810 may help organize

25 the contact list by entering new contacts that cross-reference contacts entered by the user 815, such as entering the contact information for Dr. Brown also under "Physician".

The intelligent personal assistant 810 may help the user 815 manage the user's task list application 865. For example, the intelligent personal assistant 810 may enter information for a new task, read the task list to the user when the user may not be able to

30 view the text display of the computing device, such as when the user is driving an automobile, and remind the user of tasks that are due in the near future. The intelligent personal assistant 810 may remind the user 815 of a task with a higher importance rating that is due in the near future using a voice with a higher volume and more urgent affect.

Some personal information management application programs may include voice mail and phone call functions (not shown). The intelligent personal assistant 810 may help manage the voice mail messages received by the user 815, such as by playing messages, saving messages, or reporting the status of messages (e.g., how many new

5   messages have been received). The intelligent personal assistant 810 may remind the user 815 that a new message has not been played using a voice with higher volume and more urgent affect when more time has passed than typical for the user to check his voice mail messages.

The intelligent personal assistant 810 may help the user manage the user's phone

10   calls. The intelligent personal assistant 810 may act as if the intelligent personal assistant 810 is a virtual secretary for the user 815 by receiving and selectively processing received phone calls. For example, when the user is busy and does not want to receive phone calls, the intelligent personal assistant 810 may not notify the user about an incoming call. The intelligent personal assistant 810 may selectively notify the user about incoming phone

15   calls based on a priority scheme in which the user specifies a list of people from whom the user will speak with if a phone call is received, or will speak with if a phone call is received under particular conditions specified by the user, for example, even when the user is busy.

The intelligent personal assistant 810 also may be able to organize and present

20   news to the user 815. The intelligent personal assistant 810 may use news sources and categories of news based on the user's typical patterns. Additionally or alternatively, the user 815 may select news sources and categories for the intelligent personal assistant 810 to use.

The user 815 may select the modality through which the intelligent personal

25   assistant 810 produces output, such as whether the intelligent personal assistant produces only speech output, only text output on a display, or both speech and text output. The user 815 may indicate by using speech input or clicking a mute button that the intelligent personal assistant 810 is only to use text output.

FIG. 9 illustrates an architecture 900 of an intelligent personal assistant helping a

30   user to operate applications in a computing device. The intelligent personal assistant 910 may assist the user 915 across various application programs or functions. As described with respect to FIGS. 3 and 7, intelligent personal assistant 910 interacts with the user 915 and the application programs 920 in a computing device, including basic functions

relating to the device itself and applications running on the device such as enterprise applications. The intelligent personal assistant 910 similarly uses the social intelligence engine 945 including an information extractor 950, an adaptation engine 955, a verbal generator 960, and an affect generator 965.

5   Some example of basic functions relating to a computing device itself are checking battery status 925, opening or closing an application program 930, 935, and synchronizing data 940, among many other functions. The intelligent personal assistant 910 may interact with the user 915 concerning the status of the battery 925 in the computing device. For example, the intelligent personal assistant 910 may report that the

10   battery is running low when the battery is running lower than ten percent (or other user defined threshold) of the battery's capacity. The intelligent personal assistant 910 may make suggestions, such as dimming the screen or closing some applications, and send the commands to accomplish those functions when the user 915 accepts the suggestions.

       The intelligent personal assistant 910 may interact with the user 915 to switch

15   applications by using an open application program 930 function and a close application program 935 function. For example, the intelligent personal assistant 910 may close a particular spreadsheet file and open a particular word processing document when the user indicates that a particular word processing document should be opened because the user typically closes the particular spreadsheet file when opening the particular word

20   processing document.

       The intelligent personal assistant 910 may interact with the user to synchronize data 940 between two computing devices. For example, the intelligent personal assistant 910 may send commands to copy personal management information from a portable computing device, such as a PDA, to a desktop computing device. The user 915 may

25   request that the devices be synchronized without specifying what information is to be synchronized. The intelligent personal assistant 910 may synchronize appropriate personal management information based on the user's typical pattern of keeping contact and task list information synchronized on the desktop but not copying appointment information that resides only in the PDA.

30   Beyond the basic functions for operating a computing device itself, the intelligent personal assistant 910 can help a user operate a wide range of applications running on the computing device. Examples of enterprise applications for an intelligent personal

assistant 901 are business reports, budget management, project management, manufacturing monitoring, inventory control, purchase, sales, learning and training.

On mobile enterprise portals, an intelligent personal assistant 910 can provide tremendous assistance to the user 915 by prioritizing and pushing out important and

5   urgent information. The context-defining method for applications in the intelligent social agent architecture guides the intelligent personal assistant 910 in this matter. For example, the intelligent personal assistant 910 can push out the alerts of sales drop in top priority either by displaying it on the screen or saying it to the user. The intelligent personal assistant 910 adapts its verbal style to make it straightforward and concise,

10   speaks a little faster, and appears concerned such as with slight frowning in the case of sales-drop alert. The intelligent personal assistant 910 can present the business reports such as sales reports, acquisition reports and project status such as a production timeline to the user through speech or graphical display. The intelligent personal assistant 910 would push out or mark any emergent or serious problems in these matters. The

15   intelligent personal assistant 910 may present approval requests to the managers in a simple and straightforward method so that the user can immediately grasp the most critical information instead of taking numerous steps to dig out the information by him/herself.

FIG. 10 illustrates an architecture 1000 of an intelligent personal assistant helping

20   a user to use a computing device for entertainment. Using the intelligent personal assistant for entertainment may increase the user's willingness to interact with the intelligent personal assistant for non-entertainment applications. The intelligent personal assistant 1010 may assist the user 1015 across various entertainment application programs. As described with respect to FIGS. 3 and 7, intelligent personal assistant 1010

25   interacts with the user 1015 and the computing device entertainment programs 1020, such as by participating in games, providing narrative entertainment, and performing as an entertainer. The intelligent personal assistant 1010 similarly uses the social intelligence engine 1030, including an information extractor 1035, an adaptation engine 1040, a verbal generator 1045, and an affect generator 1050.

30   The intelligent personal assistant 1010 may interact with the user 1015 by participating in computing device-based games. For example, the intelligent personal assistant 1010 may act as a participant when playing a game with the user, for example, a card game or other computing device-based game, such as an animated car racing game

or chess game. The intelligent personal assistant 1010 may interact with the user in a more exaggerated manner when helping the user 1015 use the computing device for entertainment than when helping the user with non-entertainment application programs. For example, the intelligent personal assistant 1010 may speak louder, use colloquial

5   expressions, laugh, move its eyebrows up and down often, and open its eyes widely when playing a game with the user. When the user wins a competitive game against the intelligent personal assistant 1010, the intelligent personal assistant may praise the user 1015, or when the user loses to the intelligent personal assistant, the intelligent personal assistant may console the user, compliment the user, or discuss how to improve.

10   The intelligent personal assistant 1010 may act as an entertainment companion by providing narrative entertainment, such as by reading stories or re-narrating sporting events to the user while the user is driving an automobile or telling jokes to the user when the user is bored or tired. The intelligent personal assistant 1010 may perform as an entertainer, such as by appearing to sing music lyrics (which may be referred to as "lip-

15   synching") or, when an intelligent personal assistant 1010 is represented as a full-bodied agent, dancing to music to entertain.

Implementations may include a method or process, an apparatus or system, or computer software on a computer medium. It will be understood that various modifications may be made without departing from the spirit and scope of the following

20   claims. For example, advantageous results still could be achieved if steps of the disclosed techniques were performed in a different order and/or if components in the disclosed systems were combined in a different manner and/or replaced or supplemented by other components.

WHAT IS CLAIMED IS:

1.   A computer-implemented method for implementing an intelligent personal assistant comprising:

receiving an input associated with a user and an input associated with an application program;

5   accessing a user profile associated with the user;

extracting context information from the received input; and

processing the context information and the user profile to produce an adaptive response by the intelligent personal assistant.

2.   The method of claim 1 wherein:

10   the application program is a personal information management application program, and

the adaptive response by the intelligent personal assistant is associated with the personal information management application program.

3.   The method of claim 1 wherein:

15   the application program is an application program to operate a computing device, and

the adaptive response by the intelligent personal assistant is associated with operating the computing device.

4.   The method of claim 1 wherein:

20   the application program is an entertainment application program, and

the adaptive response by the intelligent personal assistant is associated with the entertainment application program.

5.   The method of claim 4 wherein:

the entertainment application program is a game, and

25   the adaptive response by the intelligent personal assistant is associated with the game.

6.   A computer-readable medium or propagated signal having embodied thereon a computer program configured to implement an intelligent personal assistant, the medium comprising a code segment configured to:

receive an input associated with a user and an input associated with an application

5   program;

access a user profile associated with the user;

extract context information from the received input; and

process the context information and the user profile to produce an adaptive response by the intelligent personal assistant.

10   7.   The medium of claim 6 wherein:

the application program is a personal information management application program, and

the adaptive response by the intelligent personal assistant is associated with the personal information management application program.

15   8.   The medium of claim 6 wherein:

the application program is an application program to operate a computing device, and

the adaptive response by the intelligent personal assistant is associated with operating the computing device.

20   9.   The medium of claim 6 wherein:

the application program is an entertainment application program, and

the adaptive response by the intelligent personal assistant is associated with the entertainment application program.

10.   The medium of claim 9 wherein:

25   the entertainment application program is a game, and

the adaptive response by the intelligent personal assistant is associated with the game.

11.   A system for implementing a intelligent personal assistant, the system comprising a processor connected to a storage device and one or more input/output devices, wherein the processor is configured to:

receive an input associated with a user and an input associated with an application program;

access a user profile associated with the user;

extract context information from the received input; and

process the context information and the user profile to produce an adaptive response by the intelligent personal assistant.

12.   The system of claim 11 wherein:

the application program is a personal information management application program, and

the adaptive response by the intelligent personal assistant is associated with the personal information management application program.

13.   The system of claim 11 wherein:

the application program is an application program to operate a computing device, and

the adaptive response by the intelligent personal assistant is associated with operating the computing device.

14.   The system of claim 11 wherein:

the application program is an entertainment application program, and

the adaptive response by the intelligent personal assistant is associated with the entertainment application program.

15.   The system of claim 14 wherein:

the entertainment application program is a game, and

the adaptive response by the intelligent personal assistant is associated with the game.

16.   An apparatus for implementing an intelligent social agent, the apparatus comprising:

an information extractor configured to:

access a user profile associated with the user,

5   receive an input associated with a user, and

extract context information from the received input;

an adaptation engine configured to:

receive the context information and the user profile from the information extractor, and process the context information and the user profile to produce an

10   adaptive output; and

an output generator configured to:

receive the adaptive output from the adaptation engine, and represent the adaptive output in the intelligent social agent.

17.   The apparatus of claim 16 wherein the input is physiological data

15   associated with the user and the information extractor is configured to receive the physiological data.

18.   The apparatus of claim 16 wherein the input is application program information associated with the user and the information extractor is configured to receive application program information associated with the user.

20   19.   The apparatus of claim 16 wherein the information extractor is further configured to extract information about an affective state of the user from the received input.

20.   The apparatus of claim 19 wherein the information extractor is configured to extract information about an affective state of the user based on physiological

25   information associated with the user.

21.   The apparatus of claim 19 wherein the information extractor configured to extract information about an affective state of the user is configured to extract information about an affective state of the user based on vocal analysis information associated with the user by extracting verbal content and analyzing speech characteristics

30   of the user.

22.   The apparatus of claim 19 wherein the information extractor configured to extract information about an affective state of the user is configured to extract information about an affective state of the user based on verbal information from the received input.

23.   The apparatus of claim 16 wherein the information extractor configured to extract context information is configured to extract a geographical position of the user by using a global positioning system.

24.   The apparatus of claim 23 wherein the information extractor configured to extract context information is configured to extract information based on the geographical position of the user.

25.   The apparatus of claim 16 wherein the information extractor configured to extract context information is configured to extract information about the application content associated with the user.

26.   The apparatus of claim 16 wherein the information extractor configured to extract context information is configured to extract information about a linguistic style of the user from the received input.

27.   The apparatus of claim 16 wherein:

the output generator is a verbal generator;

the adaptation engine configured to produce an adaptive output is configured to produce a verbal expression; and

the verbal generator produces the verbal expression in the intelligent social agent.

28.   The apparatus of claim 16 wherein:

the generator is an affect generator;

the adaptation engine configured to produce an adaptive output is configured to produce a facial expression; and

the affect generator represents the facial expression in the intelligent social agent.

29.   The apparatus of claim 16 wherein the output generator is a multi-modal output generator that represents the adaptive output in the intelligent social agent using at least one of a first mode and a second mode.

30.   The apparatus of claim 29 wherein:

5   the first mode is a verbal mode;

the second mode is an affect mode;

the adaptive engine configured to produce an adaptive output is configured to:

produce a facial expression, and

produce an verbal expression; and

10   the multi-modal output generator represents the facial expression and the verbal expression in the intelligent social agent.

31.   The apparatus of claim 16 wherein:

the adaptation engine is further configured to produce an emotional expression to be represented by the intelligent social agent; and

15   the output generator is configured to represent the emotional expression in the intelligent social agent.

32.   A mobile device for implementing an intelligent social agent that interacts with a user, the mobile device comprising:

a processor connected to a memory and one or more input/output devices;

20   a social intelligence engine configured to interact with the processor, the social intelligence engine including:

an information extractor configured to:

access a user profile associated with the user,

receive an input associated with a user, and

25   extract context information from the received input;

an adaptation engine configured to:

receive the context information and the user profile from the information extractor, and process the context information and the user profile to produce an adaptive output; and

an output generator configured to:

receive the adaptive output from the adaptation engine, and represent the adaptive output in the intelligent social agent.

33.   The mobile device of claim 32 wherein the input is physiological data associated with the user and the information extractor is configured to receive the physiological data.

34.   The mobile device of claim 32 wherein the input is application program information associated with the user and the information extractor is configured to receive the application program information.

35.   The mobile device of claim 32 wherein the information extractor is further configured to extract information about an affective state of the user from the received input.

36.   The mobile device of claim 35 wherein the information extractor is configured to extract information about an affective state of the user based on physiological information associated with the user.

37.   The mobile device of claim 35 wherein the information extractor configured to extract information about an affective state of the user is configured to extract information about an affective state of the user based on vocal analysis information associated with the user by extracting verbal content and analyzing speech characteristics of the user from the received input.

38.   The mobile device of claim 35 wherein the information extractor configured to extract information about an affective state of the user is configured to extract information about an affective state of the user based on verbal information from the received input.

39.   The mobile device of claim 32 wherein the information extractor configured to extract context information is configured to extract a geographical position of the user by using a global positioning system.

40.   The mobile device of claim 35 wherein the information extractor configured to extract context information is configured to extract information based on the geographical position of the user.

41.   The mobile device of claim 32 wherein information extractor configured to extract context information is configured to extract information about the application content associated with the user.

42.   The mobile device of claim 32 wherein information extractor configured to extract context information is configured to extract information about a linguistic style of the user from the received input.

43.   The mobile device of claim 32 wherein:

the output generator is a verbal generator;

the adaptation engine configured to produce an adaptive output is configured to produce a verbal expression; and

the verbal generator produces the verbal expression in the intelligent social agent.

44.   The mobile device of claim 32 wherein:

the generator is an affect generator;

the adaptation engine configured to produce an adaptive output is configured to produce a facial expression; and

the affect generator represents the facial expression in the intelligent social agent.

45.   The mobile device of claim 32 wherein the output generator is a multi-modal output generator that represents the adaptive output in the intelligent social agent using at least one of a first mode and a second mode.

46.   The mobile device of claim 45 wherein:

the first mode is a verbal mode;

the second mode is an affect mode;

the adaptive engine configured to produce an adaptive output is configured to:

produce a facial expression, and

produce an verbal expression; and

the multi-modal output generator represents the facial expression and the verbal expression in the intelligent social agent.

47.   The mobile device of claim 32 wherein:

the adaptation engine is further configured to produce an emotional expression to be represented by the intelligent social agent; and

the output generator is configured to represent the emotional expression in the intelligent social agent.

48.   A method for implementing an intelligent social agent, the method comprising:

receiving an input associated with a user;

accessing a user profile associated with the user;

extracting context information from the received input; and

processing the context information and the user profile to produce an adaptive output to be represented by the intelligent social agent.

49.   The method of claim 48 wherein the input associated with the user comprises physiological data associated with the user.

50.   The method of claim 48 wherein the input associated with the user comprises application program information associated with the user.

51.   The method of claim 48 wherein extracting context information comprises extracting information about an affective state of the user.

52.   The method of claim 51 wherein extracting information about an affective state of the user is based on physiological information associated with the user.

53.   The method of claim 51 wherein extracting information about an affective state of the user is based on vocal analysis information associated with the user.

54.   The method of claim 51 wherein extracting information about an affective state of the user is based on verbal information from the user.

55.   The method of claim 48 wherein extracting context information comprises extracting a geographical position of the user.

56.   The method of claim 55 wherein extracting context information comprises extracting information based on the geographical position of the user.

57. The method of claim 48 wherein extracting context information comprises extracting information about the application content associated with the user.

58. The method of claim 48 wherein extracting context information comprises extracting information about a linguistic style of the user.

59. The method of claim 48 wherein the adaptive output comprises a verbal expression to be represented by the intelligent social agent.

60. The method of claim 48 wherein the adaptive output comprises a facial expression to be represented by the intelligent social agent.

61. The method of claim 48 wherein an adaptive output comprises an emotional expression to be represented by the intelligent social agent.

100

109
108 102
103
104
106
107
105

COMPUTER

I/O UNIT 130

110

MEMORY 140

150

STORAGE

152

OPERATING
SYSTEM

120

CPU

154

APPLICATION
PROGRAM

160

COMMUNICATION
MODULE

175

170

NETWORK

FIG. 1

200

Personal Digital Assistant

FIG. 2

300

FIG. 3

400A

```
┌──────────────────────────────┐  410A
│   RECEIVE PHYSIOLOGICAL DATA  │
│        ABOUT THE USER         │
└──────────────────────────────┘
              │
              ▼
┌──────────────────────────────┐  415A
│  DETERMINE HYPTOTHESIS FOR    │
│    AFFECTIVE STATE OF USER    │
│ BASED ON PHYSIOLOGICAL DATA   │
└──────────────────────────────┘
              │
              ▼
┌──────────────────────────────┐  420A
│   RECEIVE VOCAL ANALYSIS DATA │
│                              │
└──────────────────────────────┘
              │
              ▼
┌──────────────────────────────┐  425A
│   DETERMINE HYPOTHESIS FOR    │
│    AFFECTIVE STATE OF USER    │
│    BASED ON VOCAL ANALYSIS    │
└──────────────────────────────┘
              │
              ▼
┌──────────────────────────────┐  430A
│     RECEIVE VERBAL CONTENT    │
│                              │
└──────────────────────────────┘
              │
              ▼
┌──────────────────────────────┐  435A
│   DETERMINE HYPOTHESIS FOR    │
│    AFFECTIVE STATE OF USER    │
│   BASED ON VERBAL CONTENT     │
└──────────────────────────────┘
              │
              ▼
┌──────────────────────────────┐  440A
│   INTEGRATE AFFECTIVE STATE   │
│  HYPOTHESES AND DETERMINE     │
│   AFFECTIVE STATE OF USER     │
└──────────────────────────────┘
```

FIG. 4A

400B

RECEIVE PHYSIOLOGICAL DATA
ABOUT THE USER   410B

RECEIVE VOCAL ANALYSIS DATA   420B

DETERMINE HYPTOTHESIS FOR
AFFECTIVE STATE OF USER
BASED ON PHYSIOLOGICAL DATA   415B

DETERMINE HYPOTHESIS FOR
AFFECTIVE STATE OF USER
BASED ON VOCAL ANALYSIS   425B

RECEIVE VERBAL CONTENT   430B

DETERMINE HYPOTHESIS FOR
AFFECTIVE STATE OF USER
BASED ON VERBAL CONTENT   435B

INTEGRATE AFFECTIVE STATE
HYPOTHESES AND DETERMINE
AFFECTIVE STATE OF USER   440B

FIG. 4B

500

510

```
RECEIVE CONTENT AND CONTEXT INFORMATION
```

515

```
ACCESS BASIC USER PROFILE
```

520

```
ADJUST CONTENT AND CONTEXT INFORMATION BASED ON USER PROFILE INFORMATION
```

525

```
MODIFY INTELLIGENT SOCIAL AGENT BASED
ON ADJUSTED CONTENT AND CONTEXT INFORMATION
```

530

```
PERFORM ESSENTIAL ACTIONS IN APPLICATION PROGRAM
```

535

```
DETERMINE APPROPRIATE VERBAL EXPRESSION FOR INTELLIGENT SOCIAL AGENT
```

540

```
DETERMINE APPROPRIATE EMOTIONAL EXPRESSION FOR INTELLIGENT SOCIAL AGENT
```

545

```
GENERATE APPROPRIATE VERBAL EXPRESSION FOR INTELLIGENT SOCIAL AGENT
```

550

```
GENERATE APPROPRIATE AFFECT FOR FACIAL EXPRESSION OF INTELLIGENT SOCIAL AGENT
```

```
GENERATE APPROPRIATE AFFECT FOR VOCAL EXPRESSION OF INTELLIGENT SOCIAL AGENT
```

555

FIG. 5

600

```
                     ┌──────────────────────────────────────────────┐  605
                     │         ACCESS BASIC USER PROFILE            │
                     └──────────────────────────────────────────────┘
                                        │
                                        ▼                              610
                     ┌──────────────────────────────────────────────┐
                     │  RECEIVE ROLE OF INTELLIGENT SOCIAL AGENT FOR APPLICATION PROGRAM  │
                     └──────────────────────────────────────────────┘
                                        │
                                        ▼                              620
               ┌──────────────────────────────────────────────────────┐
               │ APPLY APPEAL RULE TO SELECT VISUAL APPEARANCE FOR INTELLIGENT SOCIAL AGENT │
               └──────────────────────────────────────────────────────┘
                                        │
                                        ▼                              630
         ┌──────────────────────────────────────────────────────────────┐
         │ APPLY APPROPRIATENESS RULE TO MODIFY VISUAL APPEARANCE FOR INTELLIGENT SOCIAL AGENT │
         └──────────────────────────────────────────────────────────────┘
                                        │
                                        ▼                              640
                   ┌──────────────────────────────────────────┐
                   │ PRESENT VISUAL APPEARANCE FOR INTELLIGENT SOCIAL AGENT │
                   └──────────────────────────────────────────┘
                                        │
                                        ▼                              650
                   ┌──────────────────────────────────────────┐
                   │ APPLY APPEAL RULE TO SELECT VOICE FOR INTELLIGENT SOCIAL AGENT │
                   └──────────────────────────────────────────┘
                                        │
                                        ▼                              660
               ┌──────────────────────────────────────────────────────┐
               │ APPLY APPROPRIATENESS RULE TO MODIFY VOICE FOR INTELLIGENT SOCIAL AGENT │
               └──────────────────────────────────────────────────────┘
                                        │
                                        ▼                              670
                   ┌──────────────────────────────────────────┐
                   │     PRESENT VOICE FOR INTELLIGENT SOCIAL AGENT     │
                   └──────────────────────────────────────────┘
                                        │
                                        ▼                              680
                   ┌──────────────────────────────────────────┐
                   │   ASSOICATE INTELLIGENT SOCIAL AGENT WITH A USER   │
                   └──────────────────────────────────────────┘
```

FIG. 6

700

USER 710

INTELLIGENT PERSONAL ASSISTANT 730

SOCIAL INTELLIGENCE ENGINE

735

VERBAL GENERATOR 755

AFFECT GENERATOR 760

ADAPTATION ENGINE 750

INFORMATION EXTRACTOR 745

710

APPLICATION PROGRAMS

PERSONAL INFORMATION MANAGEMENT 715

COMPUTING DEVICE OPERATION 720

ENTERTAINMENT APPLICATIONS 725

FIG. 7

800

USER — 815

810

INTELLIGENT PERSONAL ASSISTANT

SOCIAL INTELLIGENCE ENGINE — 825

| VERBAL GENERATOR | AFFECT GENERATOR |

840

ADAPTATION ENGINE — 835

845

INFORMATION EXTRACTOR — 830

820

PERSONAL INFORMATION MANAGEMENT APPLICATION PROGRAMS

850 — EMAIL

CALENDAR — 855

860 — CONTACTS

TASK LIST — 865

FIG. 8

900

USER ~915

910

INTELLIGENT PERSONAL ASSISTANT

SOCIAL INTELLIGENCE ENGINE

| VERBAL GENERATOR ~960 | | AFFECT GENERATOR ~965 |

~945

ADAPTATION ENGINE ~955

INFORMATION EXTRACTOR ~950

COMPUTING DEVICE OPERATION APPLICATION PROGRAM ~920

925 ~ BATTERY STATUS

OPEN APPLICATION PROGRAM ~930

935 ~ CLOSE APPLICATION PROGRAM

SYNCHRONIZE DATA ~940

FIG. 9

FIG. 10